REVIEWS

Physiologic Aspects of Survival *and* Emergency Rations

QUARTERMASTER FOOD AND CONTAINER INSTITUTE FOR THE ARMED FORCES

physiologic aspects of SURVIVAL AND EMERGENCY RATIONS

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In order to survive until rescue, the castaway must reduce to a minimum the adverse physiologic effects due to environment, so that he does not die from exposure; he must conquer fear; he must either find potable water, or at least keep his body water losses to a minimum; he must replace salt losses; and finally, for a period of long survival, he must have access to food. These five factors are listed in a sequence approximating relative importance; let us examine them in greater detail.

Environmental protection is of first importance. Occasionally, the environment may be irremediable, as for example, when a flier is ditched into very cold waters such as those around the Aleutians. Here, death from exposure is reputed to occur in less than an hour. In the majority of circumstances, however, certain steps can be taken to cope with environment. Thus, in the Arctic, provided the survivor is adequately clothed against freezing, it will be of further aid to try to avoid sweating and to favor ventilation by opening clothing at the neck and wrists and loosening the waist. The vascular circulation should be aided by wearing clothing loosely. Dry grass or kapok from airplane cushions makes excellent insulation for the feet. Clothing can be kept as dry as possible to deter freezing. Shelter can be improvised by building "bough dens" reinforced with snow, or snow caves, and by the judicious use of snow banks. In the summer, sunburn can be guarded against, and sun glasses may be improvised to prevent snow-blindness.

Appropriate steps can also be taken in the tropics. Staying in the shade and other measures sparing of body water are of paramount importance, for obviously here the problem of water and salt is critical. The need for avoiding mosquitoes is more or less a well known precaution, as well as the use of malaria-suppressant

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drugs. Shelter from both sun and rain is usually facilitated by the profusion of trees and other vegetation. Measures to avoid ticks, leeches, spiders, scorpions, and the like must also be taken. Protection against poinsonous and irritating plants is also necessary.

Control of one's fear, or conversely, bravado, is considered by many to be of almost equal importance with the necessity for controlling environmental disadvantages. Many a castaway on a raft has hastened the end by resorting to large quantities of sea water as a means of assuaging thirst. Many a castaway on land has hastened the end by an unjudicious decision to travel in the height of the sun. The continuing desire to live may be listed as one personal trait that stands out in importance above others. If, then, it be granted - as it is universally - that food may favorably influence the kind of decision which the castaway makes, and aids morale and courage, it follows that a survival ration may be a significant factor in saving life.

The need for water is not immediate, but it may arise early in the course of survival, depending on the environmental temperature and the amount of physical exercise. Table 1, taken from Army Air Forces Manual 64-0-1, illustrates this point. While certain measures can be taken to conserve water, the minimum daily quantity required for the average person in a temperate environment has been estimated by Gamble to be about 700 cc. This is, of course, considerably less than the amount normally consumed, which may average about 2.5 liters or more, depending on work and temperature. An interesting and important point about the body's requirement for water is that it may be profoundly influenced by the kind and amount of food that is available. Protein increases the requirement, while carbohydrate and fat decrease it.

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TABLE 1

DESERT WATER DATA TABLE

Maximum Daytime Temperatures In Shade	Entire Water Supply Per Man	Approximate Survival Days (When Resting In Shade At All Times)	Approximate Survival Days (When Traveling Only At Night & Resting In Shade By Day. Also Distance You Can Travel)	
VERY HOT 100°F. & above	No water	2-5	1-3 days	20 miles
	1 quart	2-5½	2-3½ days	20 miles
	2 quarts	2-6	2-3½ days	25 miles
	4 quarts	2½-7	2½-4 days	30 miles
MODERATELY HOT 80°-100°F.	No water	5-9	3-7 days	20-40 miles
	1 quart	5½-10	3½-7½ days	20-45 miles
	2 quarts	6-11	3½-8 days	25-50 miles
	4 quarts	7-13	4-9 days	30-60 miles
COOL Under 80°F.	No water	9-10	7-8 days	40-60 miles
	1 quart	10-11	7½-8½ days	45-75 miles
	2 quarts	11-12	8-9 days	55-100 miles
	4 quarts	13-14½	9½-11 days	60-150 miles

Adapted from: Army Air Forces Manual 64-0-1, "Survival", June 1945.

Nutrition Board, National Research Council, lists five grams daily as being a liberal allowance, but further designates the average normal intake of salt to be as high as 10-15 grams per day, when water intake is not more than 4 liters. For every liter of intake above four, an additional gram of salt is recommended. It would seem, however, that once adjusted to the environment, the average person may not need as much as this, for the salt concentration of sweat is then considerably lower. Basically, the needs are to replenish the salt lost by the body.

It is a truism that the castaway rarely dies from starvation.* The specific physiologic need for food in a survival situation is not a critical one, although as mentioned above, the psychologic aspects of the problem probably make food quite important from the overall standpoint. Insofar as actual starvation and its attendant inanition are concerned, it is reported that the castaway on a raft can "survive without food, but with ample water, for twenty to thirty days or longer, provided he is not subjected to physical strain, ..." This may be contrasted with average survival time without water, which probably does not exceed ten to fourteen days even under the most favorable circumstances. At sea, the maximum recorded period of survival without water is eleven days and it can be considerably less than that in some individuals.

It does not seem that all the nutritive components of food are needed in the same degree for survival. For preventing physical deterioration, calories and protein rate highest. (There is, however, a definite limit on the amount of protein that should be eaten, for the metabolic end products increase obligatory urine volume). Except for sodium, (as salt), minerals are not a critical factor. For the relatively short periods ordinarily involved in survival, there is no evidence from the

* Thus, in the Arctic, clothing, shelter and signalling devices, fuel and heat, water may be listed as taking precedence over food; in the tropics, environmental protection, salt and water play a more important direct role than food.

physiologic standpoint justifying any concern for vitamins, provided the castaway was not originally in a depleted state.* Vitamin supplements may, on the other hand, exert a favorable psychologic effect, if they can fit into the ration conveniently.

Having rapidly reviewed the hierarchy of factors involved in survival, let us examine more closely the components of water balance, as a preliminary to considering the types of food suitable for a survival ration. The components of water exchange when there is no food intake are indicated in Figure 1. There are two items of expenditure; (1) water which leaves the body as water vapor by way of the lungs and skin - the so-called insensible loss, and (2) water removed by the kidneys. This total outgo is only in small part covered by water produced by oxidation of protein, fat, and carbohydrate. In fasting, there is an additional source of water from the cellular breakdown of body substance, but this does not contribute to general dehydration. As Gamble states: "This is water which, under the circumstances imposed by fasting, is physiologically expendible." In fasting, this source of fluid, together with water of oxidation, aids in maintainance of homeostasis. It will be noted from the diagram that water drunk under guidance of the sensation of thirst usually provides a generous margin over obligatory expenditure, indicated by the broken line, and so leaves a large surplus to be removed in the urine. One exception to this occurs in extremely hot environment, however, where thirst may not be a dependable guide to water requirements.

The larger component of the obligatory outgo of fluid is the insensible expenditure, and since this has a direct relationship to the metabolism of energy, it is apparent that at rest, it will be at a minimum. In the tropics, this is the basis for recommendations to avoid physical activity as much as possible, and to decrease the vaporization of body water as much as is compatible with maintaining body temperature. Usually the castaway in the tropics intuitively takes measures to

* This statement might possibly require modification if survival periods exceeded, say, three weeks.

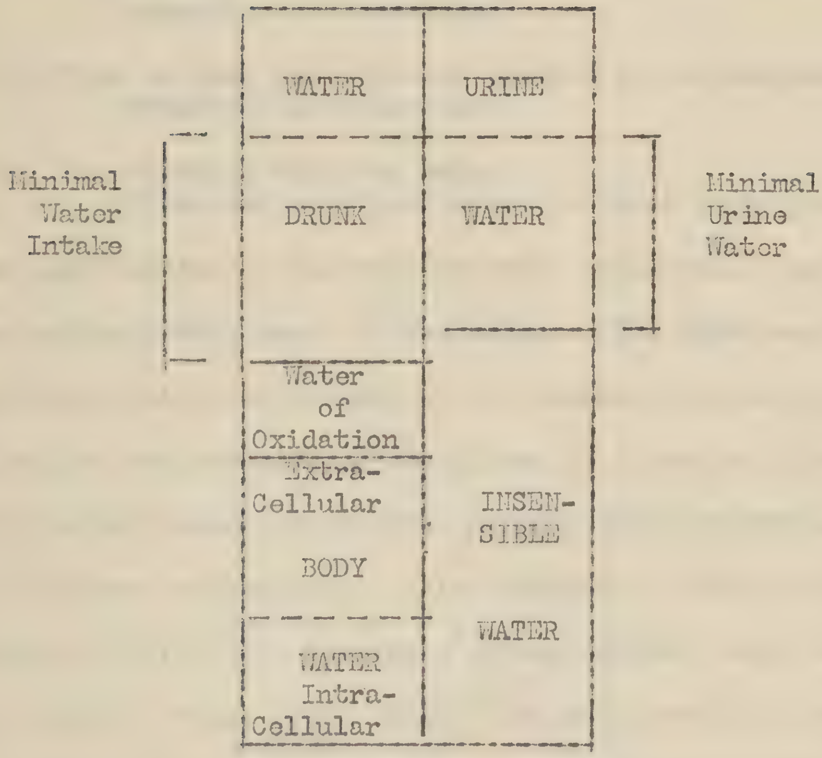

*FIG. 1. WATER EXCHANGE DURING FASTING, WITH SURPLUS WATER INTAKE.

*Taken from: "The Water Requirement of Castaways" by James L. Gamble, Proc. Am. Philosp. Society, Vol. 88, #3, 1944.

decrease environmental warmth, and to substitute for the vaporization of body water other processes of heat removal. These measures are the following:

(1) Stay in the shade.
(Direct reduction of environmental temperature)

(2) Increase the cooling effect of breeze by removal of clothing.
(Promotion of convection)

(3) When at sea, periodically immerse in the sea water.
(Promotion of conduction)

(4) Wet clothing with sea water.
(Vaporization of sea water in place of body water)

An appreciation of the minimum water requirement can be gained by considering the concentrating power of the kidney. The total amount of metabolic solutes requiring excretion, divided by the maximum concentration that is ordinarily found to be within the capacity of the kidney (1.4 osmolar), provides a measure of the obligatory urine water. A specific example cited by Gamble illustrates the principle. A 24-hour collection of urine amounted to 1240 cc. having a freezing point depression of -1.19°C. An osmole of any solute lowers the freezing point of water by -1.86°C. Thus, $\frac{1.19}{1.86} \times 1240 = 794$ milliosmols of total solutes requiring excretion; and $\frac{794}{1.4} = 566$ cc. minimal urine volume, provided there is no impairment in kidney concentrating power.

Now, it is important to note that the urinary volume can be even further decreased if the castaway eats a type of food sparing body protein. This is usually considered to be carbohydrate, although fat may exert a similar effect, which may, however, be complicated by the production of a concurrent Ketosis. A specific example of the effect of carbohydrate can be cited, again taken from Gamble. Table 2

presents the essential data. It is seen that, when compared with the results found in fasting, feeding of 100 gm. of glucose has two effects upon water balance: (1) favorable - in that renal water is decreased, and (2) unfavorable - in that there is a decrease in the amount of body water arising from extracellular and intracellular sources. Since, however, the latter is less than the former, the net result is a gain of 140 cc. of water to the individual, as well as a sparing of his bodily tissue. Thus, 100 cc. of the water requirement for fasting can be replaced by glucose, and the incident benefits of glucose (tendency to avoid inanition and lassitude, and to maintain cheerfulness) are obtained. In addition, carbohydrate, when taken in sufficient quantity, prevents the characteristic Ketosis of starvation.

TABLE 2

EFFECT OF GLUCOSE ON WATER EXCHANGE

Subject M. G.	Minimal Urine Water, cc.	Available Body Water, cc.
Fasting	521	518
100 gm. glucose	223	360
Reduction	298	158

Gain in water exchange 298-158= 140 cc.

Values average per 24 hrs. for 6-day periods omitting first day.

Taken from: "The Water Requirement of Castaways" by James L. Gamble, Proc. Am. Philosp. Society, Vol. 88, #3, 1944.

Table 3 indicates the role that organic acids of Ketosis may play. It is seen that the absence of these substances when glucose is given accounts for thirty-eight percent of the total reduction in solute output. Thus, both the anti-Ketogenic effect of glucose and its protein sparing effect reduce the solute

output, and thereby conserve body water.

TABLE 3

EFFECT OF GLUCOSE ON OUTPUT OF SOLUTES IN URINE

Subject--M.G.	Milliosmols per 24 Hrs.			
	Total Solutes	Organic Acids	NH_4	Org. Ac. + NH_4
Fasting	784	133	86	219
100 gm. glucose	362	39	21	60
Reduction	422	94 +	65 =	159

159/422 0.38
Data from 6-day periods (omitting first day).

Taken from: "The Water Requirement of Castaways" by James L. Gamble, Proc. Am. Philosp. Society, Vol. 88, #3, 1944.

There is yet another factor, although a slight one, involved in water balance. This pertains to water of oxidation. Table 4 indicates the relative amounts of water produced by the oxidation of 1 gram of carbohydrate, fat or protein. It will be noted that the water of oxidation of fat is high by comparison, but more importantly, that of protein is least - another reason why the level of protein consumed in the absence of water must be limited.

TABLE 4

WATER OF OXIDATION FROM FOOD

Substrate of oxidation 1 gm.	H_2O produced (gm.)
Glucose	0.600
Sucrose	0.579
Starch or glycogen	0.556
Fat	1.071
Protein	0.396

In summary, the following points are salient for the conservation of the body water of the castaway:

(1) in isolation, where water supply is a problem, the type of food consumed may play an important role in prevention of rapid dehydration

(2) the chief component of food adversely affecting water balance is protein, because its metabolic end products require water for excretion, and less important, its water of oxidation is less than that of carbohydrate or fat

(3) carbohydrate and fat exert a protein-sparing effect, and thus decrease the amount of obligatory urine. Carbohydrate also aids in preventing Ketosis, and is much less nauseating than are equal quantities of fat.

(4) insensible loss of body water should be kept at a minimum by limiting activity and promoting cooling.

Turning now to the application of these principles to the development of rations, it will be recalled that one of the early survival rations - the Life Raft

Ration - was composed of 100 grams of pure carbohydrate in the form of Charms candy. On the basis of the foregoing, it is apparent that this ration was based on sound physiologic principles. The other Survival or Emergency Ration, the D Bar, contained other nutrients that were surprisingly close in quantity to the amounts presently proposed, as we shall see. However, there were also several objections to these rations on acceptability grounds. Thus the candy ration was reported to cause sore mouths and to be unappetizing for any length of time exceeding a day or two. Candy is thirst provoking to many. The D Bar depressed appetite, caused gastro-intestinal upsets in some and, in general, was claimed to be thirst provoking because of the chocolate content. These rations were, therefore, not ideal; yet, in retrospect, they had several happy properties in relation to size, shape, stability, and caloric density. In addition, they could play an important role in contributing to the morale of the subject. At this point, we might digress momentarily to state that to many, the psychologic problems of survival far outweigh the physiologic. This feeling about the relative unimportance of what (and if) one eats in survival circumstances is seen in such statements as "the best survival ration is a rapid rescue", and others of that nature. This line of thought might be pursued further, however. If food is to be provided for psychologic reasons primarily, there is still no reason why it should not also be physiologically sound and of such a nature as to conserve physical and mental efficiency. After rescue, overall recovery with return to duty, wound healing, etc., will proceed at a far faster rate when extreme depletion has been prevented. By all criteria, therefore, if a survival ration is to be made, it should not be planned oblivious of food values.

In 1943 there occurred the most important technologic achievement of the war, as far as survival is concerned. This was the rendering of sea water potable by a desalination technique. A solar still was also developed. The upshot of these

advances was that in many situations at sea, dehydration was no longer the factor completely limiting the kind of food that could be used in survival. It was estimated that an average 800 cc. of water could be depended upon daily as the combined output from desalination kit, solar still, and from rainfall. This turn of events roused again the conviction that many had held previously; namely, that while survival rations must necessarily be high in calories and sparing of body water, they should nevertheless contain familiar and well-liked food items, should be less confection-like, and furthermore, should contain as much protein as possible in the interests of preventing marked loss of body protein. The big question was -- how much protein could be incorporated for a water intake presumably averaging 800 cc. per day, and what source of protein would favor the attainment of nitrogen balance? This last factor involved the amino acid make-up of protein -- and this was a field only recently explored, insofar as the familiar human foods were concerned. As a means of obtaining the needed information, several research projects were established through the Committee on Food Research, Quartermaster Food & Container Institute for the Armed Forces. Within the past two years, valuable information has been obtained, not only relating to these immediate problems, but also in the basic physiology of low-calorie, low-protein feeding. These will be discussed briefly.

Early in the program of investigation, there emerged one finding that appears to be basic in feeding the small amounts of food characteristic of survival rations. Swanson, working at Iowa State College, found that egg protein apparently conserved body protein in protein-depleted animals, and caused an unexpectedly marked reduction in the amount of urinary nitrogen excreted on a protein-free diet. This work was then repeated and verified by Swanson, as well as by Allison and co-workers at Rutgers University, using rats and dogs respectively as test animals. Furthermore,

this effect was similar to that obtained when an equivalent amount of dietary nitrogen was supplied in the form of the ten essential amino acids. The effect seemed to be related to the high methionine content of egg protein, for the addition of dl-methionine to diets containing proteins other than egg resulted in greater nitrogen sparing.

Here was an exciting possibility for use in survival ration planning. However, verification in human subjects was needed. This was undertaken initially by Schwimmer and co-workers at New York University. It was later investigated by R. M. Johnson and co-workers* at the University of Southern California, and also coincidently by Cox and co-workers at Washington University School of Medicine, St. Louis, and at New York University. The overall results were strikingly similar, and served to point up the great care needed in applying to humans results obtained by animal experimentation, even though the latter is a necessary and important forerunner. For in the human, no nitrogen-sparing effect due to added methionine was found such as that observed in rats and dogs. The conclusion was reached that a difference in species requirement for methionine was responsible for the difference in results.

At about the same time, additional work was begun on other phases of the low protein, low caloric intake problem by Schwimmer and associates. Comprehensive investigations upon several series of human volunteers undergoing twenty-eight dietary regimens were carried out. These investigations were based on the previous findings discussed above, and were designed to investigate several important questions that had arisen as a consequence. The resulting data, together with those originally obtained, form the basis for the present planning of the Survival

* Under the direction of Dr. H. J. Deuel.

ration. The immediate applicable findings* of the New York group were these:

1. Nitrogen sparing is absent in the 400-500 calorie range of feeding (level of standard Life Raft Ration).
2. Nitrogen utilization is optimal at 1500-1800 calories when 20 grams of protein (derived from dehydrated fermented egg white) are fed. When 40 grams are fed, a striking improvement in nitrogen balance occurs at all levels from 900 to 1800 calories, and the net amount of nitrogen retained by the body is greatest at the 40 gram protein intake level.
3. Urinary volumes are <u>not increased</u> when as much as 20 and 40 grams of protein are fed at 1500-1800 calories, averaging 30-60 cc. <u>less</u> than when no protein is ingested at 450 calories, and 115-145 cc. <u>less</u> than when 10 grams of protein are given at 450 calories.

In addition, the superiority of egg white over certain other types of protein was again reported. This was significant, for it provided verification of the earlier findings in animals that were withheld from application to survival ration planning when the species difference in the methionine effect was uncovered. The findings of Schwimmer and co-workers showed very clearly that for short periods of time, when egg white was the sole source of protein, there was a marked reduction in nitrogen excretion** as compared with the results obtained when lactalbumen (high ash content) or malted milk protein was used, or no protein at all. This same effect was obtained at both the 20 and 40 gram levels of protein intake. The basis for the apparently superior effect of egg protein over many other proteins is apparent from a tabulation of the amino acid content of egg white and whole egg versus certain other foods. See Table 5.

* These findings were obtained over experimental periods of 5 days only, however.

** It is recognized that to some, nitrogen-balance considerations may not be acceptable as a criterion for Survival feeding policy; i.e., blood protein and hemoglobin regeneration may be equally valid criteria.

(It will be noted that the egg white and whole egg values per 100 grams exceed man's average requirements -- Columns 1, 2, and 3 -- while none of the other common proteins approach the egg in biologic value, considering all the component amino acids, with the prominent exception of SERUM PROTEIN.

Using egg white and whole egg values as criteria, zein, ricin, peanut flour, soybean meal, and wheat flour would have marked amino acid deficiencies, quantitatively speaking, when used as the only source of protein. (NOTE: It is quite possible that if some of these proteins were used together in a ration, they would supplement each other to the extent of obviating the quantitative deficiencies they have individually.))

Other important data were obtained from this series of investigations. It was found that the frequency of feeding (one feeding versus four versus twelve) had no statistically significant effect upon the sparing of nitrogen or upon urine volume. The principle of frequent feeding requires further investigation, however, because it is reported that in the Arctic an overall feeling of well-being occurs from eating more often, and also because of the general belief that more efficient utilization of food in the body is promoted by feeding a given amount of food in small quantities as compared with a single large quantity.

Increase of caloric output did not appear to affect nitrogen balance or urine volume to any great extent. This finding, too, should be checked, for it is an important point. It may have a bearing on the situation in the Arctic where a greater amount of energy is needed, presumably due to factors not encountered in warmer regions such as (1) need for maintaining body temperature; (2) direct effect of cold upon B.M.R. when shivering or its preceding muscular tenseness occurs; (3) "hobbling" effect of Arctic clothing, which increases the caloric cost of any activity. It will be recalled that dietary protein at low levels of intake may or may not be used for tissue repair and replacement purposes depending on the fraction of the daily energy requirement that is supplied. Thus, in the Arctic, if a survival

TABLE 5

APPROXIMATE PERCENTAGE OF AMINO ACIDS IN VARIOUS FOODS (BLOCK & BOLLING)

AMINO ACIDS	1 MAN'S AVERAGE REQS.* gm.	2 EGG WHITE	3 WHOLE EGG	4 EGG YOLK	5 EGG ALBUMIN	6 SERUM PROTEINS	7 CASEIN	8 LACTAL-BUMIN	9 WHOLE MILK - COW
ARGININE	3.5	5.8		8.2	5.7±0.3	5.8±0.3	4.1±0.2	3.5±0.5	4.3
HISTIDINE	2.0	2.2		2.6	1.8±0.3	2.6±0.1	2.5±0.3	2.0±0.3	2.5
LYSINE	5.2	6.5		5.5	4.5±0.5	8.0±0.4	6.9±0.7	8.0±1.1	7.5
TYROSINE	3.9	4.8		5.3	4.2±0.1	5.4±0.3	6.4±0.4	5.3±0.1	5.3
TRYPTOPHANE	1.1	1.6±0.2		1.6±0.2	1.4±0.2	1.7±0.1	1.8±0.2	2.3±0.3	1.6
PHENYLALANINE	4.4	5.5		5.7	6	5.4	5.2±0.5	5.6	5.7
CYSTINE	3.8**	2.3±0.4		1.9	1.7±0.2	3.6±0.1	0.36±0.04	3.0±0.2	1.2
METHIONINE		4.4		2-3	5.0±0.3	2.1	3.5±0.3	2.8±0.2	2.8
SERINE					7.6		6-7	4.9	
THREONINE	3.5		4.9		3-4	6.3	3.9±0.1	5.3	4.6
LEUCINE	9.1		19.0±2.1		9.4	18	12.1	15[a]	
ISOLEUCINE	3.3		5.3±0.3			3	6.5		
VALINE	3.8		4.4±0.6		6.8	6	7.0	4	
GLUTAMIC ACID					16.3±0.2		22.8		
ASPARTIC ACID					8.2±0.2		6.3		
GLYCINE			2.5		1.9		0.5		
ALANINE					7.4		5.6	0-1	
PROLINE					4-5		8.2		
HYDROXYPROLINE						0	2		

* Calculated
** Cystine plus Methionine
a Leucine and isoleucine

TABLE 5 (Cont'd)

APPROXIMATE PERCENTAGE OF AMINO ACIDS IN VARIOUS FOODS

AMINO ACIDS	10 ZEIN	11 RICIN	12 PEANUT FLOUR	13 SOYBEAN MEAL	14 WHEAT FLOUR
ARGININE	1.6±0.2	11.7	9.9	5.8	3.9
HISTIDINE	0.9±0.2	0.0	2.1	2.3	2.2
LYSINE	0.0	6	3.0	5.4	1.9
TYROSINE	5.0±1.2	2.7	4.4	4.1	3.8
TRYPTOPHANE	0.1	0.4	1.0	1.6	0.8
PHENYLALANINE	6.4±0.7		5.4	5.7	5.5
CYSTINE	0.8±0.1	1.0	1.6	0.6±1.4	1.9
METHIONINE	2.4		0.9	2.0	3
SERINE					
THREONINE	2.4	2.7	1.5	4.0	2.7
LEUCINE	23.7±2.1	15[aa]	5.5	6.6	12.0±2.6
ISOLEUCINE	4.3±0.4		3.4	4.7	3.7±0.2
VALINE	2.4±0.9	2	4.0	4.2	3.4±0.5
GLUTAMIC ACID	35.6	19			
ASPARTIC ACID	3.4	2			
GLYCINE	0.0		5.6		7.2
ALANINE	9.9				
PROLINE	9-12	4			
HYDROXYPROLINE	1	0			

aa Includes isoleucine

ration provides a smaller fraction of the daily energy requirement than was originally planned, the whole purpose of nitrogen-sparing might be defeated.

Another interesting and important point which has been raised by this same series of investigations concerns the effect of fat upon the sparing of nitrogen. There is now some indication that the same nitrogen-sparing effect found to occur in the 1500-1800 calorie range, can also occur at a lower calorie level, provided the fat content of the diet is increased at the expense of the carbohydrate. This finding is at once both important and potentially dangerous. It is important in that the foot soldier under survival circumstances requires as compact and calorically high a ration as can be devised for him to carry conveniently, and in that it will permit the easier carrying of emergency food for longer periods of time, while presumably inhibiting hunger. It is somewhat dangerous, however, in that the goal of high caloric density may be permitted to supersede that of highest palatability.* Any diet containing too much fat would not only be nauseating to most, but might also dispose towards a condition of ketosis and acidosis. Above all other considerations, however, there is every indication that such a ration would lack palatability - and paradoxical though it may seem, there is a considerable amount of evidence that the castaway will not "eat anything", even though starving.

It is pertinent, now, to appraise where we stand in the actual development of a survival ration. On the basis of the previously described evidence that was

* Then, too, it is desirable to supply as much of the daily caloric requirements as possible; therefore, many feel that additional fat should be considered from that standpoint, rather than only as a means of decreasing the size of the ration.

obtained through a practical and intensive program of research coordinated and brought to overall fruition through the efforts of Dr. Samuel Lepkovsky, the indications now are that the nutritional characteristics of the Survival Ration should be as follows:

a. Total caloric intake - 1800 calories per man per day.

b. Proportions of carbohydrate, fat and protein -

Protein -- 34-50 gms. per day (8-10% of calories)
Fat -- 40-60 gms. per day (20-30% of calories)
Carbohydrates -- 275-325 gms. per day (60-70% of calories)
Vitamins and minerals -- as provided in the natural food composition of the ration.

c. Food composition - Protein sources of highest nutritional value; e.g., dehydrated whole egg or egg white, rice flour, dehydrated skimmed milk; fat sources must be those likely to undergo a minimum of deterioration; carbohydrates chiefly dextrin, soluble starches, and sucrose.

d. Highest order of acceptability - Palatable, edible under temperature extremes (-50° to $+120^\circ$F.), non-thirst-provoking (subjectively), swallowed easily with restricted free water supply (approximately 800 cc. per day), and should provide variety in form, color, flavor, and consistency.

These are the requirements as set forth by Headquarters, Army Air Forces. It is highly doubtful that these same requirements can be used for other operations, particularly the foot soldier, for the size and weight requirements for an Air Force Emergency ration are very different from most others. (There is the possibility that such a ration could be dropped by the Air Force to castaways in a wide range of circumstances.) On the basis of present knowledge, a combination of

food items embodying the characteristics listed above has been developed by the combined efforts of the Quartermaster Food & Container Institute for the Armed Forces and the Aero-Medical Laboratory. It is felt by many, however, that considerable improvement can yet be made in the acceptability of these food items which represent only the initial attempt at incorporating into a ration the desired characteristics. In such efforts, one is brought face to face with the too frequently unappreciated difficulty of transposing physiologic requirements into the palatable, familiar, easily-packaged, compact, stable food items that are required ultimately for use as a ration. It is gratifying to be able to state that considerable progress along this very line has been made by the Food Development Division of the Institute. Their most recently developed food items were presented for inspection at the Survival and Emergency Ration Conference of 5 September 1947, Chicago.

Despite the definite progress that has been made in the basic physiologic aspects of the survival problem, and the equally encouraging advances in the developmental phases, there yet remain many problems which require urgent answer. As a means of pointing up the host of details involved in "perfecting" a ration, some of the more immediate problems may be enumerated. One basic problem lies in the fact that practically all of the data obtained on human volunteers are predicated on the availability of 800 cc. of drinking water a day, while living in a temperate environment. There is, of course, no real assurance that such will be available to every castaway, and what is perhaps more pertinent, there is considerable likelihood that in the Arctic such an amount would not be available unless adequate fuel for heat, and perhaps, shelter, are provided. It is strange to conceive of lack of water in the midst of ice and snow, and yet the results of recent Arctic trials indicate that for the

castaway in those regions the melting of ice would take much time and heat, particularly if he were without shelter. It is basic premise for survival feeding that the less the available quantity of drinking water, the closer one is forced towards a pure carbohydrate ration, if renal losses of body fluid are to be kept at a minimum. With further reference to the Arctic itself, there is great need for determining the effect of cold upon survival requirements.

Certain technical questions remain which may require repeating or extending the investigative work done earlier. Thus, it would be desirable to extend the experimental periods used in order to determine the effects found during experimental periods of a few weeks; it would also be desirable to compare the relative effects upon urine volume of lactalbumen and egg protein when the former is ash-free; and possibly, additional investigation might be done on the effects of methionine when added to the diet in larger and smaller amounts. Some work is already underway in these connections.

There are other problems related to determining which combinations of protein might produce an effect upon nitrogen-sparing that exceeds that found to occur when egg protein alone is used. The well-known "supplementary" value of two or more proteins used together in a diet should be exploited fully so that not only is a maximum effect obtained in the physiologic sense, but what is probably of more practical concern, so that food items may be developed without restriction as to one main type of protein. Such a restriction begets artificiality, and no artificial ration is likely to attain ultimate success.

The possibility of devising a survival ration for use in all environments is an enticing but elusive goal. There is some question as to whether or not an "all purpose" survival ration will ever be realized. It is known, for instance, that calorie requirements are much greater in the Arctic than elsewhere, due mainly

to the three factors mentioned previously. This requirement could be met by more quickly using up the supply of the survival ration, but this obviously may decrease the length of time the castaway will hold out, and if the water supply were not increased commensurately, the amount of protein consumed would be in excess from the standpoint of conserving body water. Of even more immediate importance than this, however, is the wide difference in packaging and stability requirements that characterize extremes of environment. The difficulties in the tropics would seem to be chiefly those of stability, although packaging problems there are by no means non-existent. In the Arctic, both packaging and stability are involved, in ways that may not be immediately apparent unless one visualizes the difficulties of removing packaging in the extreme cold and eating food which, although frozen when it comes into use, may have been stored previously in a heated warehouse and other supply points indoors or outdoors. The need for supplying the food in bite-sized pieces will also have to be determined, as well as the types and combinations of foods that are least thirst-provoking.

We can, however, go only so far in the laboratory toward producing a finished item that will be acceptable as the Emergency and Survival Ration. Although it is obvious that many additional research and developmental problems remain to be solved, one of the most promising directions for future progress would seem to lie in operational trials of the food items recently designed for this ration. The completion of such trials is now looked forward to as the source of critical information which will bring the Institute to the final stages of this project, and the attainment of a long sought goal. In the words of General Larkin, The Quartermaster

General of the Army: "The development of a satisfactory Survival Ration is indeed an important project, for the preservation of life is not only instinctive to man, it is also of fundamental importance for successful military operation."

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To provide the research and development and prepare the specifications for the foods, rations, and containers required by the Armed Forces; to provide an advanced technical training program for personnel intended for various subsistence assignments; to provide quality control procedures and analyses for Quartermaster supplies; to provide manufacturers with technical assistance in the production of new items; to provide for the dissemination of technical information concerning the Institute's activities; to maintain current plans for the organization and expansion of activities relating to foods and containers in time of national emergency; to represent the Office of The Quartermaster General on federal, military, and any other specification boards and on technical and scientific boards and commissions dealing with foods and containers organized by the following: National Research Council, The National Academy of Sciences, Military Testing Boards, the United States Department of Agriculture, The Federal Food and Drug Administration and other military, federal, national, or international technical organizations.